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# AN INVESTIGATION ON MECHANICAL PROPERTIES AND MICROSTRUCTURE OF Mg/Al ALLOYS USING Zn INTERLAYER DURING DIFFUSION BONDING

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***ABSTRACT***

***The general prerequisites of a part in the mechanical, automobile and aviation have given many testing conditions. New materials can be found and manufactured to some valuable segments. This work is directed to get a better understanding and portrayal of the dispersion holding of comparative and different metals. This work goes for building up a basic strategy to get diffusion bonding joints at generally not ease. In diffusion bonding, two metal surfaces are united into contact at expanded temperatures under strain for a specific timeframe. It also aimed to obtain optimum parameters for diffusion bonding of zinc coating over aluminium alloy plate and magnesium alloy. These two metals are jointed inside the die after finishing surface treatment. Then the die is kept inside the diffusion bonding machine by varying the time, temperature, pressure by means of load. Diffusion bonding equipment is fabricated and verified with experiments so that it is capable of rendering accurate diffusion bonding joints with facilities to measure parameters and to investigate the super plastic diffusion bonding joints with interlayer. This method is devised to study the mechanical and metallurgical characteristics of the joint.***

***KEYWORDS: Diffusion Bonding, Aluminium, Magnesium, Optical Microscope & SEM***

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**Original Article**

## 1. INTRODUCTION

In this examination, AZ80 magnesium alloy and AA 7075 aluminium compound are utilized for welding in the strong stage process. Numerous strategies have been concocted to improve the dissemination of compound material properties. Aluminium is the most vital metal accessible in the Earth's outside layer. Since aluminium has a lower thickness than steel, it has numerous phenomenal attributes and properties. Magnesium alloy ordinarily contends with aluminium composites for basic applications. Magnesium combination has extremely great damping capacity and throwing has been utilized under high vibration condition like helicopter gearbox. For aviation applications, for example, air ship motors, a blend of Al and Mg must be productively actualized with the goal that it can work better in high-temperature applications and mechanical properties are successful. The primary procedure parameters utilized in this procedure are temperature, weight and time. As an instrument for spreading exhaustion break of the substituted magnesium compound AZ80, a blend of microvoids has been

proposed [1]. The defensive component of the warmth, safe aluminium covering clung to magnesium/aluminium mix AZ 31, AZ 80 and AZ 91 D was assessed at 3.5% by weight. The position of% NaCl by electrochemical and weight estimation [2] The improvement of microstructure of ousted magnesium compound AZ 80 and the trademark highlights of β - Mg 17 Al 12 stage precipitation under different warmth treatment conditions were contemplated. The reason for dispersion holding is to frame the intersection so the surfaces of the two sections are associated close enough together, which is near inter diffusion.

## 2. EXPERIMENTAL WORK

The experimental work was getting ready for the assessment of base metal properties. The aluminium compound seems extended coarser grains however the magnesium combinations show up equiaxed fine grains. The creation of disparate amalgams zinc covering over the aluminium plate which is 5 mm thickness and AZ80 Magnesium plate 10 mm thickness were cut into the required estimations (45 × 45 mm) by cutting with power hacksaw and pursued by granulating activity. The cleaned and synthetically treated workpiece of Mg/Al was stacked in a bite the dust made up of 316 L hardened steel. The concoction organization and mechanical properties of the base metals are portrayed in tables 1 and 2. The schematic graph for the dissemination diffusion bonding setup has appeared in figure 1. The readied tests were warmed up to the holding temperature utilizing the acceptance heater with the warming rate of 25˚C/min; at the same time, the required weight was connected. By thusly, first, different temperature and alternate parameters weight and time as consistent and vice-versa. Magnesium plate is bonded with zinc covering over aluminium plate and it appeared in the figure 2.

**Table 1: Chemical Composition of AZ80 Magnesium Alloy and AA7075 Aluminium Alloy**

| Elements | Wt. (%) | |
|---|---|---|
| | AZ80 Mg | AA 7075 |
| **Mg** | 90.591 | 2.1 |
| **Al** | 8.36 | 90.02 |
| **Zn** | 0.75 | 5.1 |
| **Cu** | 0.002 | 1.2 |
| **Fe** | 0.0037 | 0.5 |
| **Si** | 0.033 | 0.4 |
| **Mn** | 0.26 | 0.3 |
| **Ni** | 0.00056 | 0.38 |

**Table 2: Mechanical Properties of the Base Metals**

| Base Metal | Crystal Structure | Melting Point ˚C | Density Kg/m$^3$ | Ultimate Tensile Strength (MPa | Elongation % | Shear strength (MPa) |
|---|---|---|---|---|---|---|
| Aluminium **(AA7075)** | FCC | 650 | $2.7\times10^3$ | 569 | 10.89 | 340 |
| Magnesium **(AZ80)** | HCP | 649 | $1.75\times10^3$ | 344 | 14.2 | 192 |

Diffusion bonding tests were performed on zinc covered examples on AZ 80 magnesium compound and AA 7075 aluminium composite. The impact of temperature on the dispersion fortified example of zinc covering on AZ80 magnesium combination and AA 7075 aluminium compound was inspected and observed to be 15 minutes. Likewise, weight and time were changed.

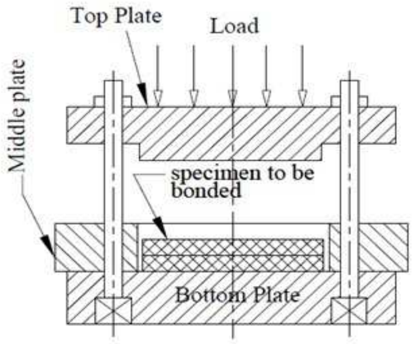


**Figure 1: Diffusion Bonding Die Setup**

## 3. RESULTS AND DISCUSSIONS

### 3.1 Mechanical Testing

The transverse tensile tests are conducted on various diffusion bonded specimens and the fractured specimens are shown in Figure 2. The evaluation of the diffusion bonded joints fabricated under different experimental conditions with variables such as temperature, pressure and time were explained in the earlier section and the results were summarized and tabulated and is given in below Table 3. The failure mechanism is much needed in terms of industrial point of view as it results in loss of raw material. This increases the production cost, thereby increases the final product resulting in an elevated market price.

**Figure 2 Lap Shear test examples (Before and After Test)**

**Table 3: Results of Lap Shear Test of Magnesium AZ80 Plate and Zinc Coating over Aluminium Alloy 7075 Plate**

| Sl. No. | Bonding Temperature (˚C) | Bonding Pressure (MPa) | Bonding Time (min) | Lap Shear Strength (MPa) |
|---|---|---|---|---|
| **Effect of Temperature** | | | | |
| 1 | 325 | 10 | 15 | - |
| 2 | 350 | 10 | 15 | 14 |
| 3 | 375 | 10 | 15 | 21 |
| 4 | 400 | 10 | 15 | - |
| **Effect of Pressure** | | | | |
| 5 | 375 | 2 | 15 | - |
| 6 | 375 | 5 | 15 | 22 |
| 7 | 375 | 15 | 15 | 27 |
| 8 | 375 | 20 | 15 | 30 |
| 9 | 375 | 25 | 15 | - |
| **Effect of Time** | | | | |
| 10 | 375 | 10 | 2 | - |
| 11 | 375 | 10 | 5 | 15 |
| 12 | 375 | 10 | 30 | 27 |
| 13 | 375 | 10 | 60 | - |

The lap shear strength (LSS) for Zinc coated Mg/Al alloy at higher temperatures, various pressure and temperatures is given in figure 4.8. For the temperature of 375° C, the LSS esteem was observed to associate with 21 MPa. The lap shear strength (LSS) as for the weight was found to demonstrate an expanding pattern. For the pressure of 5 MPa, the LSS was found to be around 22 MPa, whereas, for the pressure of 20 MPa, it is found to possess 30 MPa. With respect to time also, the LSS value shows an increasing trend. From these above preliminaries, it very well may be inferred that the ideal temperature, weight and time for the zinc covered Mg/Al interface can be thought to be 375° C, 20 MPa and 30 minutes for which the examples have higher LSS.

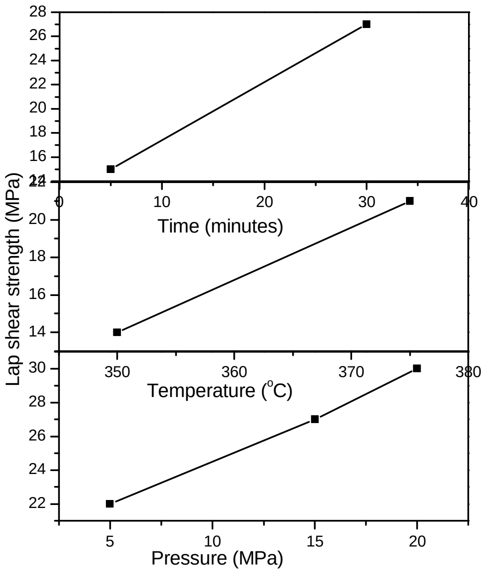


**Figure 3: The Lap Shear Strength (LSS) for Zinc Covered Mg/Al Combination at Higher Temperatures, Different Weight and Temperatures**

### 3.2 Metallurgical Testing

#### 3.2.1 Optical Microscope

The interface layer could be envisioned from the infinitesimal examination. Figure 4 speaks to the photographic picture at different example temperatures of 350 ºC and 375ºC.

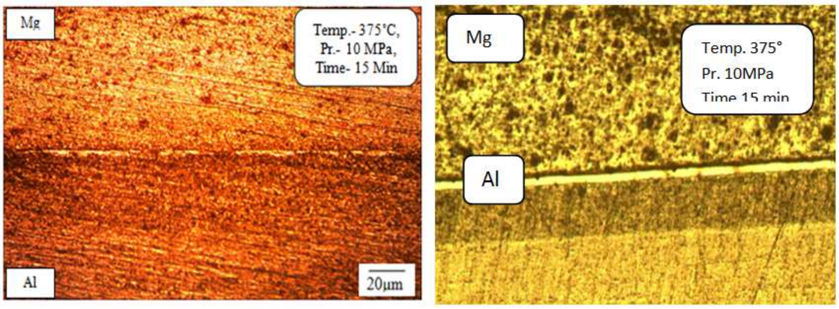


**Figure 4: Optical Microscope Images of Mg/Al Alloy at Various Sample Temperatures**

The diffusion of both the layers could well be correlated to the lap shear strength (LSS). At lower temperature of 350˚ C, the interface region is very thin. As the temperature is increased the diffusion layer increases which could be seen from our earlier discussion of LSS with an increased strength in both the values. The LSS value increases from 14 MPa to 21 MPa. As the temperature is further increased to 375˚ C, the width of the mid diffusion layer increases. While considering the

strength of the same sample under investigation we could easily observe a marginal decrease in the strength. This may be attributed to the grain growth due to the increased temperature. The LSS value of 21 MPa is obtained for the same. Similar kind of diffusion layer could be observed in the earlier literature for aluminium/magnesium based interfaces. The increase in hardness is due to the formation of $Mg_2Al_3$ and $Mg_{17}Al_{12}$ intermetallic compound (IMC) compounds during the high retention time, and this IMC formation during solidification is better than the aluminium and magnesium parent alloys Resulting in an increase in mechanical properties.

### 3.2.2 Scanning Electron Microscopy (SEM)

Scanning Electron microscope (SEM) is utilized to examine the superficially morphology of the dispersion verified example. In the present examination, the SEM picture of Mg/Al compound composite was doling out. The streamlined all around verified examples that were warmed to 375º C was used in this examination. The holding weight was kept at 10 MPa with a holding time of 15 min. The all-around diffused examples were cut into the required measurement and along these lines, the SEM picture is resolved to break down the dispersion system.

The SEM images at magnifications area unit shown in Figure 5.

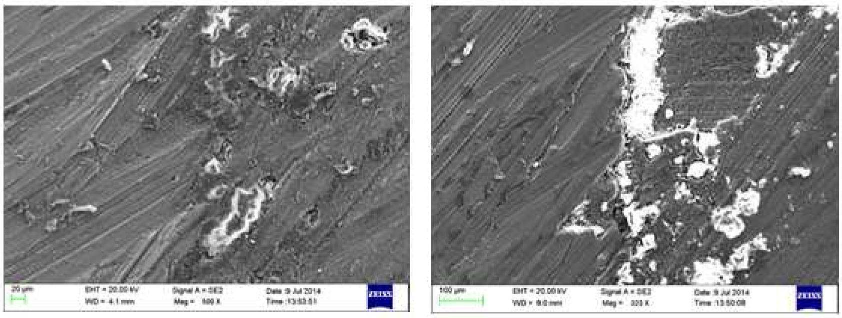

**Figure 5: SEM Morphology at Different Magnifications**

## 4. CONCLUSIONS

For the AZ80 aluminium-bonded magnesium alloy and AA 7075 aluminium alloy, diffusion bonding tests were conducted for various series of process parameters. AZ 80 magnesium alloy with zinc coating and AA 7075 aluminium alloy were tested for diffusion bonding for various sets of process parameters. In order to assess the quality of adhesion, a connecting piece was made, a tensile shear tensile test specimen manufactured under these conditions, and the results of these experiments confirmed that at temperatures lower than poor bonding of samples were obtained whereas above 375˚ C deformed samples were obtained. Hence the present aim on investigation on failure analysis is to optimize the conditions so that the final resulting product does not elevate the cost price of the final welded joints of the parent material.

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